Naval Submarine Medical Research Laboratory

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A CLINICAL TRIAL OF A COMPUTER DIAGNOSIS PROGRAM FOR CHEST PAIN

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Released by:
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Naval Medical Research and Development Command
Research Work Unit 3706N-M0095.005-5010

Approved and released by

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Summary Page

THE PROBLEM

To determine whether NSMRL computer program to diagnose chest pain is suitable for use by corpsmen at sea.

THE FINDINGS

132 patients with confirmed diagnoses of chest pain (myocardial infarction, angina, chest infection, or other) presenting at Naval Hospitals at Portsmouth, Charleston, and San Diego were diagnosed by the emergency room physicians and the NSMRL computer program. The percentage of correct diagnoses by the computer (72%) was not significantly different from the percentage of correct diagnoses by the ER physicians (79%). The physicians were significantly better than the computer program at distinguishing myocardial infarction from angina. However, the computer program was equally successful at determining whether a patient was suffering from myocardial infarction.

APPLICATION

The computer program for diagnosing chest pain should be of assistance to the independent duty corpsman in the diagnosis and management of patients aboard submarines presenting with chest pain.

Administrative Information

This investigation was conducted under Naval Medical Research and Development Command Research Work Unit 63706N - M0095.005-5010, "Sea trials for computer-based medical diagnostic/patient management system for use aboard SSN/SSBN submarines." It was submitted for review on 25 July 1990, approved for publication on 7 December 1990, and has been designated as Naval Submarine Medical Research Laboratory Report No. 1162.

Abstract

We evaluated the performance of a computer program designed to assist corpsmen in managing patients who present at sea with chest pain. The diagnostic accuracy of the program for three common and serious causes of chest pain -- myocardial infarction (MI), angina, chest infection -- as well as its accuracy for nonspecific chest pain, was compared with that of emergency room physicians at three Naval hospitals for 132 patients. The percentage of correct diagnoses by the computer program (72%) was not significantly different from that of the physicians (79%), although the accuracy of the physicians was better. The computer program was able to distinguish MI from the other diseases as well as the physicians (i.e. was as sensitive, 83% vs. 84%) and at the same time made fewer false diagnoses of MI (i.e. was more specific). The computer's ability to distinguish among cardiac illnesses was not as good as that of the physicians and it misdiagnosed more cases of angina. The computer program is suitable for use by medical personnel practicing in isolated locations and may help improve diagnostic accuracy in cases of MI. Its failures emphasize that it cannot substitute for medical personnel, but can be helpful to medical personnel when a patient's diagnosis is uncertain.

Introduction

There has in recent years been much interest in using the computer as an aid in medical diagnosis (Rogers, Ryack, and Moeller, 1979). This interest is greatest in the submarine fleet. Physicians are assigned only to newly commissioned Trident submarines; complete responsibility for medical care otherwise rests with the ship's independent duty hospital corpsman. With neither the training nor experience of a practicing physician, the corpsman must decide whether or not to recommend a medical evacuation. To ensure that his patients receive all needed care, particularly when a patient's condition is puzzling, corpsmen find evacuation to a physician's care an attractive option. But evacuations are costly, dangerous to both the patient and the deck crew, and operationally undesirable. Reducing unnecessary evacuations is a desirable goal. Submariners, therefore, would find it useful to have a tool with a demonstrated ability to assist the corpsman in making a good decision and reducing the number of inappropriate -- that is, premature or delayed -- medical evacuations.

NSMRL has developed microcomputer-based medical support systems to aid the corpsmen in treating a variety of maladies. Some of the systems are based on one devised by de Dombal (1973; 1979), but they have been specifically tailored for the submarine population (Osborne, 1984; Ryack, 1987). One provides information to aid the corpsmen in the diagnosis and management of chest pain (Southerland and Fisherkeller, 1987; Fisherkeller, Southerland, and Moeller, 1987). The corpsman, using a data collection form to guide his examination, records findings for 27 history and 20 physical exam categories. The program then provides the user with probabilities that the patient is suffering from each of four illnesses: myocardial infarction, angina, chest infection, and non-specific chest pain.

Although the program produces the probabilities for four separate diagnoses, it can be argued that it is more important for the corpsman to determine which patients are suffering from an MI (and must receive specialized care) than it is to distinguish among various other medical diagnoses. The reason is that the corpsman is trying to decide whether or not a patient must be evacuated. It would be most useful if the program would help to identify patients with MI.

Although a new program may appear to be similar to another which has been validated (de Dombal, 1973), it still requires independent validation. There have been previous field trials of such programs in the Navy (Henderson, et al., 1981), but these have sought only to determine how easily the corpsmen can use the program and how well they accept it; they have not attempted to validate the programs themselves.

This prospective validation of the chest pain program was begun to assess its reliability and consequent usefulness to independent duty corpsmen. This report compares the diagnostic accuracy of the NSMRL chest pain program with that of emergency room physicians for patients who were reasonably representative of an active duty Navy population.

METHOD

Subjects

The subjects were 132 male or female active duty or retired Navy personnel or their dependents between the ages of 15 and 50. They presented with chest pain in the emergency rooms of the Naval Hospitals at Portsmouth, VA, Charleston, SC, and San Diego, CA, from May 31, 1988 to September 30, 1988 and volunteered to participate in the study. The patients also met the requirement that they not have a prior history of myocardial infarction, angina, or such chronic illness as diabetes, since these conditions are grounds for exclusion from submarine service.

Technicians

Six research technicians -- two at each hospital -- collected the data. They were trained in the use of the chest pain data sheet by a Navy medical officer over a two-day period. The technicians worked consecutive 8-hour shifts between 8:00 a.m. and midnight, five days a week, for the four month period.

Procedure

Patients who presented at the emergency room with a complaint of chest pain were interviewed by a research technician who described the study and solicited their participation. Patients who agreed to participate in the study signed consent forms and then the technician recorded case history details while waiting for the examining physician. This included such things as the patient's sex and age, the history of smoking, previous surgery, history of MI, angina, bronchitis, previous illnesses, etc. While the patient was being examined by the physician, the technician listened to the examination and recorded the answers to the questions asked by the computer program on the data sheet shown in Figure 1. For example, the chest pain program asks the site of the pain, the presence of radiation, duration and severity of the pain, and so on. The required information could be obtained by watching the examination. The physician was asked to verbalize his findings as he conducted the examination so that the technician, listening, could complete the data sheet. Sometimes the physician was too busy to provide a complete report; in these cases the technician obtained the missing information from the patient's emergency

SSN:

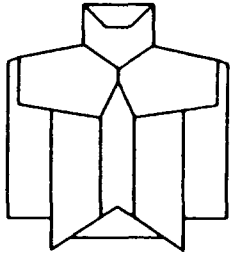
CHEST PAIN DATA SHEET

HISTORY

DATE/TIME:

AGE:

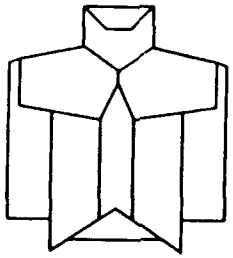
SITE OF PAIN:



CENTRAL
CHEST
ACROSS
LT. SIDE
RT. SIDE
EPIGASTRIC
OTHER

RADIATION:

YES
NO
LT. ARM
BOTH ARMS
BACK
CHEST
SHOULDERS
NECK
JAW
THROAT
FINGER/HANDS
EPIGASTRIC
OTHER



DURATION OF PAIN:

1 H OR LESS
1 - 2 H
2 - 4 H
4 - 12 H
12 - 24 H
24 - 1 W
1 W OR MORE

TYPE OF PAIN:

TIGHT GRIPPING DULL
SHARP BURNING STABBING
HVY/PRESS/CRUSH ACHING NAGGING

SEVERITY OF PAIN:
(do not ask; obvious distress = severe; everything else = moderate)

MODERATE
SEVERE

AGGRAVATING FACTORS:

MOVEMENT
COUGH
BREATHING
SITTING
LYING DOWN/REST
LEANING FORWARD
OTHER
NONE

NUMBNESS:

PRESENT
ABSENT

ONSET OF PAIN:
(sudden < 2 min; gradual > 2 min)

SUDDEN
GRADUAL

TIME COURSE OF PAIN:
(at times free of pain = intermittent; everything else = continuous)

CONTINUOUS
INTERMITTENT

PROGRESS OF PAIN:

BETTER
SAME
WORSE

RELIEVING FACTORS:
(ask about each)

NITRO
REST
WALKING
MORPHINE
OTHER DRUGS
OTHER
NONE

OTHER SYMPTOMS:

DYSPNEA:
(recent = this illness; chronic = habitual)

ABSENT
THIS ILLNESS
HABITUAL

COUGH:
(recent = this illness; chronic = habitual)

ABSENT
THIS ILLNESS
HABITUAL

SPUTUM:

ABSENT
THIS ILLNESS
HABITUAL

NAUSEA:

PRESENT
ABSENT

VOMITING:

PRESENT
ABSENT

ORTHOPNEA:
(inability to breathe except when upright)

PRESENT
ABSENT

PND:
(post-nocturnal dyspnea)

PRESENT
ABSENT

REFLUX

PRESENT
ABSENT

APPETITE:
(recent change)

NORMAL
DECREASED

BOWELS:
(recent change)

NORMAL
CONSTIPATED
DIARRHEA

PAST HISTORY

PREVIOUS CHEST PAIN:

YES
NO

PREVIOUS CARDIO-RESPIRATORY ILLNESS:

YES
NO

PREVIOUS MAJOR SURGERY:

YES
NO

SMOKER:

YES
NO

POSITIVE HISTORY FOR:

MI
ANGINA
BRONCHITIS
HYPERTENSION
DIABETES

(PLEASE TURN OVER FOR PHYSICAL EXAM PORTION)

[illegible]

[illegible]
NORMAL
INCREASED
DECREASED

PULSE RATE:
< 61
61 - 70
71 - 80
81 - 100
> 100

RESPIRATION:
< 20
20
21 - 25
26 - 30
> 30

BLOOD PRESSURE (SYSTOLIC):
< 100
101 - 120
121 - 140
141 - 160
> 160

BLOOD PRESSURE (DIASTOLIC):
< 71
71 - 80
81 - 90
91 - 100
> 101

LAB

EKG:
ST ELEVATION
T DEPRESSION
Q WAVES
ST DEPRESSION
ARRYTHMIA
NO APPARENT DISTRESS

SGOT:
< 25
25 - 50
51 - 100
101 - 200
> 200

GENERAL EXAM

MOOD:
(don't ask; obvious distress or objective symptoms = distressed; concern about illness = anxious)
NORMAL
ANXIOUS
DISTRESSED
IN SHOCK

COLOR
(consider environmental temp; check conjunctiva & palms on black & oriental)
NORMAL
PALE
FLUSHED
CYANOTIC

EXAMINATION

EDEMA:
ABSENT
ANKLES
OTHER

SWEATING:
(sweating not due to environment or exercise)
YES
NO

SHIVERING:
(shivering not due to environment or exercise)
YES
NO

COLD/CLAMMY:
YES
NO

CALVES TENDERNESS:
YES
NO

TENDERNESS:
YES
NO

RESPIRATORY MOVEMENT:
(abnormal = diff. between full inspir. & full expir. is < 2 inches of expansion is unequal between sides; everything else is normal)
NORMAL
ABNORMAL

PERCUSSION:
(percuss both front & back; dull = less resonant than normal; hyper-resonant = markedly more resonant than normal; everything else = normal)
NORMAL
DULL
HYPER-RESONANT

CHEST SOUNDS:
(compare left to right sides; rhonchi = cont. musical sounds; rales = discrete, non-cont. sounds; decreased = 1 side markedly less)
NORMAL
RHONCHI
RALES
DECREASED

JUGULAR VENOUS PULSE:
(pt. reclined at 45 deg., chin at 30 deg. to left, meniscus more than 5 dist. from clavicle to chin = elevated; everything else = normal)
NORMAL
RAISED

HEART SOUNDS:
(listen with stethoscope to 1st & 2nd heart sounds; normal = lub-dub, 1st-dub; everything else = abnormal)
NORMAL
ABNORMAL

CO-PSMAN'S EVALUATION

MARK YOUR EVALUATION TO:
( ) MYOCARDIAL INFARCTION
( ) ANGINA
( ) NON SPECIFIC CHEST PAIN
( ) CHEST INFECTION

MARK YOUR EVALUATION
( ) EVACUATION
( ) NO EVACUATION

YOUR TREATMENT:
( ) OBSERVE ONLY
( ) MEDICATE
( ) PROCEDURE

DATA SHEET SEEN BY C.O.?
( ) YES
( ) NO

RECOMMENDATION OF MEDICAL OFFICER:
( ) EVACUATION
( ) CHEST PAIN TREATMENT
( ) TREATMENT FOR OTHER
( ) RETURN TO DUTY
( ) NOT CONSULTED

treatment record. The technician was not allowed to interview the patient without the permission of the physician and was asked to leave the examining room if the patient was uncomfortable. The collected information was later entered into the computer program to obtain the computer's diagnosis.

The computer program for chest pain was written to assign the probabilities that a given patient's symptoms indicated angina, chest infection, myocardial infarction, and non-specific chest pain. The category "Angina" included both stable and unstable angina. Chest infection was defined as any infection of the pleural cavity (including pleuritis and pericorditis) which would require medical intervention, such as pneumonia or bronchitis. Cases of pneumothorax are also included in this chest pain category because they exhibit symptoms of pleuritic pain. Non-specific chest pain was defined as chest pain that is not serious, not life-threatening, and does not require urgent medical intervention. Mechanical chest discomfort and GI tract pain fall in this category.

The computer diagnoses were compared with diagnoses from two other sources. The first was the diagnosis arrived at by the examining physician in the emergency room. If the patient was admitted to the hospital, there would, of course, be further observations and tests leading to a "discharge diagnosis" entered in the patient's records. The discharge diagnosis was presumably more accurate and was accepted as the "final" diagnosis. If a patient was not admitted, there was a follow-up telephone call to the patient by a physician or nurse at least three weeks after the visit to the emergency room to determine if subsequent events cast doubt on the emergency room discharge diagnosis. If a subject had had further medical care related to the same illness, the results of that care were considered in establishing a "final" diagnosis.

In comparing the diagnosis reached by the computer program with those reached by physicians after evaluating a patient during an ER visit or a hospitalization, it is important to remember that the computer program is designed for use in isolated situations where X-rays, electrocardiograms (EKG), laboratory procedures such as creatine phosphokinase (CPK) and serum glutamate oxaloacetic acid transferase (SGOT) assays and consultations with specialists are generally not available. The diagnosis of the computer program must, therefore, be based on only a fraction of the information to which the ER physician has access.

RESULTS

Table 1 compares the final diagnoses with the diagnoses made by the emergency room physicians and with those made by the computer program. There are 132 computer diagnoses but only 130 emergency room diagnoses because two of the emergency treatment records were not available.

Table 1 shows, for example, that of the 132 cases, 9 were finally diagnosed as MI, 6 as angina, 9 as chest infection, and 108 as cases of non-specific chest pain. Overall, 79% of the diagnoses made by the emergency room physicians and 72% of the computer diagnoses agreed with the final diagnoses. These percentages are not significantly different ($t = 1.35$, $df = 129$, $p < .50$).

Table 1. Comparison of the diagnoses by the computer program and the emergency room physicians with the final diagnoses for myocardial infarction (MI), angina (AN), chest infection (CI), and non-specific chest pain (NS).

		FINAL DIAGNOSES								
		MI	AN	CI	NS		MI	AN	CI	NS
COMPUTER	MI	3				PHYSICIAN	6	2		15
	AN	5	1	1	15		1	4		5
	CI			2	4				8	1
	NS	1	5	6	89		1		1	86

Of the 9 cases of MI, the computer program accurately diagnosed 3; it misdiagnosed 5 as angina and one as non-specific chest pain. Each computer diagnosis of MI was confirmed on admission. Of 8 cases of MI, the physicians accurately diagnosed 6; they misdiagnosed one as angina and one as non-specific chest pain. (We did not have the physicians' emergency room diagnoses for the remaining MI patient.) Seventeen physician diagnoses of MI were not confirmed on admission; 15 patients were diagnosed with non-specific chest pain and 2 with angina.

The set of diagnoses established by the emergency room physicians was not significantly different from the final diagnoses, according to a Chi Square test ($X^2 = 16.95$, $df = 3$, $p < .001$).

Cardiac Event vs. Myocardial Infarction

Among patients with MI, the computer program did not accurately discriminate between MI and angina. It was predominantly this factor and several misdiagnoses of angina which produced the difference in the Chi Square results for the computer and physicians.

However, the program correctly identified all but one of the

MI patients as having either an MI or angina. If we combine MI and angina as a diagnosis of "cardiac event," the performance of the computer program and the ER physicians is much more similar (Table 2). Both the computer program and the ER physicians correctly identified all but one of the patients with MI; the computer correctly identified 106 of the 123 patients who did not have MI, and the physicians correctly identified 96 of them (the emergency room diagnosis of one of the non-MI patients is also missing). The Chi Square test now shows that the computer program diagnoses were not significantly different from the final diagnoses ($X^2 = 2.46$, df = 1, $p < .15$), whereas the ER diagnoses were significantly different from the final diagnoses ($X^2 = 5.67$, df = 1, $p < .02$).

Table 2. Comparison of computer program and emergency room physicians for final diagnosis of myocardial infarction (MI) when initial diagnosis of cardiac event (CE, i.e. MI or angina) is made.

	Computer			Physicians	
	Final Diagnosis			Final Diagnosis	
	MI	Not MI		MI	Not MI
CE	8	17	CE	7	26
Not CE	1	106	Not CE	1	96

DISCUSSION

Physicians evaluating a patient with chest pain err on the side of conservatism and admit to hospitals, often with a "rule out MI" diagnosis, three or more patients who actually turn out to have non-cardiac causes of pain for every patient who turns out to have suffered a heart attack. This approach is entirely appropriate as the risk of imminent death associated with a missed diagnosis of MI is far less acceptable than the inconvenience of a period of observation necessary to ensure that no heart damage has occurred.

The "bias" toward overdiagnosis of MI is magnified when the person providing medical care has less experience with MI patients as occurs when hospital corpsmen are caring for ship's crews alone at sea. In this context, a computer program which is about as reliable as an emergency room physician in detecting cases of MI, but which does not miss cases more frequently than physicians did, might be a useful tool to corpsmen at sea.

In terms of the overall percentage of correct diagnoses, the performance of the computer program was not significantly different from that of the emergency room physicians. This finding rests largely on the overwhelming percentage of non-specific chest pain diagnoses in the sample populations. The physicians were better at distinguishing among specific illnesses. The program did not do well at diagnosing angina, for example.

But in evaluating the performance of the computer program designed for use on submarines and in comparing its accuracy with that of physicians, it is necessary to remember that the physicians had access to a variety of other diagnostic information not available to the program: detailed interpretation of EKGs, CPK assays, chest X-rays, and consultations with specialists. It is also necessary to remember that the primary purpose of the computer program is to help the independent duty corpsman faced with a puzzling case to distinguish between chest pain stemming from an MI and other causes of chest pain. The program's ability to specify precisely what illness the patient actually has is not as critical as its ability to correctly categorize the illness as an MI or some other condition. In this restricted sense, the performance of the program is about the same as that of the ER physicians.

Other computer programs have been reported to diagnose MI quite accurately. Goldman and his colleagues (1982, 1988) have reported that their program was significantly more specific than were ER physicians. In an earlier study (Goldman, Weinberg, Weisberg, et al., 1982), they identified nine critical questions which bear on the presence or absence of MI. One of them, however, is not appropriate to submariners; it is whether or not this same pain was previously diagnosed as MI. If this had been the case, the man would not be serving on submarines. Further, it is important to note that in their recent report (Goldman, Cook,

Brand, et al., 1988) we see that the information requested by their very first question -- "ST elevation or Q waves in 2 or more leads, not known to be old?" -- is not available on submarines. Independent duty corpsmen are not routinely trained to make detailed evaluations of EKGs, and most do not have EKG equipment available. Similarly, another question in Goldman's algorithm asks about EKG changes associated with ischemia or strain. This information, too, is not available to most independent duty corpsmen. Thus, a program which may work very well in a typical hospital may be ineffective at sea.[1]

We hasten to emphasize that this study shows that the computer program makes errors. It erroneously categorizes the source of the pain in about one quarter of the patients. In about one percent of the cases, it incorrectly suggested that a person suffering from MI had some other problem. In 13% of the cases, it suggested inaccurately that a person was suffering from cardiac chest pain. The magnitude of these errors is similar for physicians and underlines the need for the user to make an independent and careful evaluation of the advice provided by the program.

Like the emergency room physicians, independent duty hospital corpsmen have much more information available to them in treating an individual case than is collected by the computer program. The program gathers only 47 responses; most of them are either "yes" or "no." The corpsman at sea generally has a detailed knowledge of the patient, his past history and behavior, and an acute awareness of the degree that the patient's present condition deviates from the norm. In every case, the corpsman, particularly when aided by additional information as is provided by the computer program, might be expected to be a more capable diagnostician than the computer program by itself. The corpsman's insight and judgment remain indispensable at sea.

A final point should be stressed. Rogers, Ryack, and Moeller (1979) pointed out that the usefulness of these programs depends not simply on their being reasonably accurate but on being more accurate than the diagnostician for whom the program is intended. Since the purpose of the computer program is to serve as a diagnostic aid to the independent duty submarine corpsmen, its performance should be compared with that of a corpsmen practicing at sea. Information bearing on the accuracy of corpsmen diagnoses is being collected. The present comparison with physicians serves only to illustrate that the program is not wildly inaccurate when compared with a generally acceptable standard.

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[1] Work is in progress to adapt Goldman's program to isolated Navy situations.

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medical personnel practicing in isolated locations and may help improve diagnostic accuracy in cases of MI. Its failures emphasize that it cannot substitute for medical personnel, but can be helpful to medical personnel when a patient's diagnosis is uncertain.